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IFIM/PHABSIM APPLICATION SCOPING STUDY:

RIVER VYRNWY
COUND BROOK
BOW BROOK

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Final report to National Rivers Authority
Severn Trent Region

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Executive summary

The objective of this study is to assess the applicability of the Instream Flow Incremental Methodology (IFIM) using the Physical Habitat Simulation System (PHABSIM) to three study rivers, identified by National River Authority Severn Trent staff as being affected by changes in flow regime. The rivers identified are the River Vyrnwy, the Cound Brook, and the Bow Brook. The summer flow regime of the Vrynwy may be increased as part of the proposed National Water Resources Strategy with the perceived impact that there will be changes in the summer habitat of brown trout, salmon (fry and juvenile life stages) and chub (spawning life stage). The summer flow regimes of the Cound and Bow brooks are influenced by abstractions with a consequent perceived reduction in habitat for brown trout (fry and juvenile life stages).

The findings of this report are based on visual surveys of the rivers and meetings with NRA staff. On the R. Vyrnwy and the Cound Brook IFIM studies are recommended and potential study sites are identified. IFIM studies on the Bow Brook are not recommended at present because of perceived problems associated with water quality.

On the R. Vrynwy two IFIM study reaches have been identified, sampling two distinct zones identified within the length of river in question. On the Cound Brook one site has been selected to represent the complete zone of interest. IFIM application on the Bow Brook is not recommended before fuller consideration of the problems associated with water quality. In the lower reaches of the Bow Brook it appears that extremely high levels of macrophyte growth, possibly associated with high nutrient levels, influence habitat availability to a much greater extent than flow reductions from abstraction. The portion of the Bow upstream of the outfall at Crowle was, by contrast, relatively free of macrophyte growth at the time of the survey. Although a representative IFIM study site has been selected, an IFIM application is not recommended since the impact of abstraction upon flows is likely to be less severe than in the lower portion of the brook.

Within each of the proposed study reaches a range of macro-habitat types have been identified including riffles (shallow areas of fast, turbulent flow), runs (areas of shallow to medium depth with moderately fast, smooth flow), and pools (deep with slow, smooth flows). For each of the sites an estimate of the number of study transects required is given, as well as suggestions for the timing of such studies. The availability of the necessary habit suitability data for each of the target species life stages in question is limited to Category I type curves (curves generated from expert knowledge and available literature) and it is recommended that these should be assessed by NRA Severn Trent region fisheries staff. In order to properly examine the impact of the potential changes in flow on the R. Vyrnwy and the abstractions on the Cound and Bow brooks it is also recommended that time series of flow data should be produced for each of the recommended study sites both with and without the proposed/existing artificial influences.

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1 Introduction

1.1 INSTREAM FLOW INCREMENTAL METHODOLOGY

The Instream Flow Incremental Methodology (IFIM) (Bovee, 1982) has been developed as a tool for environmental impact assessment since 1976, by the Aquatic Systems Branch of the U.S. Fish & Wildlife Service. The IFIM allows the quantification of a measure of physical habitat area ("Weighted Usable Area") available to target aquatic species. The IFIM is implemented using the Physical HABitat SIMulation (PHABSIM) computer model. Calibration of hydraulic models within PHABSIM on the basis of field observations of the microhabitat variables depth, mean column velocity, and substrate type facilitates the prediction of change in physical habitat area with discharge. A detailed guide to the data collection methods used in a PHABSIM study is given in Johnson et al (1991) (updated 1994). Evidence based in IFIM predictions has frequently been upheld in disputes over water resources in the USA where it is by far the most commonly preferred method for assessing minimum acceptable flows.

The IFIM using PHABSIM has been assessed for use in the UK under national NRA R&D Project 282 "Ecologically Acceptable Flows" (Johnson et al, 1993 (1)), by application at eleven study sites on a wide range of different types of rivers. The first application of the IFIM to a current UK operational water resources problem was carried out in 1992, at sites on the River Allen in Dorset, by the Institute of Hydrology and National Rivers Authority

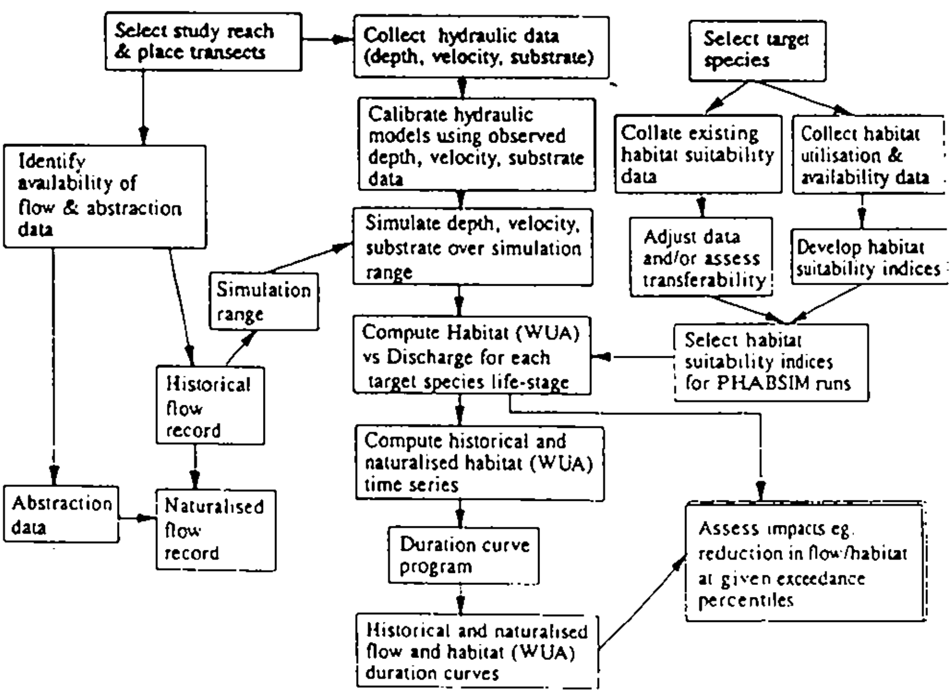

Figure 1.1 *Procedure for IFIM assessment of impact of abstraction upon habitat availability*

Wessex Region (Johnson et al 1993(2)). The IFIM has since been applied to water resources problems on the Rivers Bray and Barle (commissioned by NRA South Western Region) (Johnson et al, 1994) and it is currently being employed by NRA Thames Region as part of an investigation into the impact of groundwater abstraction upon the ecology of the River Kennet. Additionally, a further study is at present being undertaken by IH and NRA South Western Region with the IFIM being applied to three sites in the River Piddle catchment. A flow chart giving an outline of the steps involved in applying the IFIM using PHABSIM to assess the impact of a change in flow regime (in this case a historical abstraction regime) upon the availability of physical habitat to selected target species is shown in Figure 1.1.

1.2 THE RIVER VYRNWY

The area of the River Vyrnwy under consideration lies between Lake Vyrnwy (Grid Ref: SJ019191) and the confluence of the Vyrnwy with the River Severn (SJ328158). Its situation, along with the other rivers under examination, within the NRA Severn Trent region is shown in Figure 1.2. This site was selected for assessment due to a proposed change in the summer flow regime of the river (impact period April-October) which has potential impacts on fish biology and fisheries.

The flow regime of the river is largely controlled by releases from Lake Vyrnwy (compensation flow at present is 45Mld (total flow at low flows = 60Mld approx)) and as a result there is a large difference between the summer and winter flow regimes with flow increasing approximately tenfold in winter when spill from the lake is large. Summer flows are usually between 100-200Mld with those experienced in winter being in the order of 1000-2000Mld. The river changes from being a slow flowing, low water level river in the summer to being a fast flowing, deep, river in winter. Under the proposed water resource management scheme, the flows in the April-October period would be increased to approximately 200-400Mld. There is no perceived problem with water quality within the area in question.

The proposed changes may have effects on fish biology and fisheries downstream of the Lake Vyrnwy reservoir, with potential impact on emergent/juvenile salmonids and spawning coarse fish, especially chub, due to increased water surface levels and velocities. Similarly, there may also be an impact on other fauna due to the increases in wetted area that would result from the change in flows. The distribution of salmon, within the area of the Vyrnwy in question, is limited by the waterfall and HEP plant sited at Dolanog (SJ068127) (as shown in Figure 1.3) which forms a barrier to fish migration. Above Dolanog the fish population is dominated by trout. Further downstream the fishery becomes mixed/coarse in the area of Llansantffraid (SJ226204). The river has significant angling value up to Meiford (SJ157128), although there is also a trout fishery between Dolanog and Pontrobert (SJ106127). The particular species/life-stages of interest and the areas where they may be found may be summarised as follows:

Salmon (emergent/juvenile): between Dolanog and Llansantfraid
Trout (emergent/juvenile): D/S of Lake Vyrnwy to Llansantfraid
Chub (spawning): from the confluence of the Vyrnwy and the Severn to Newbridge.

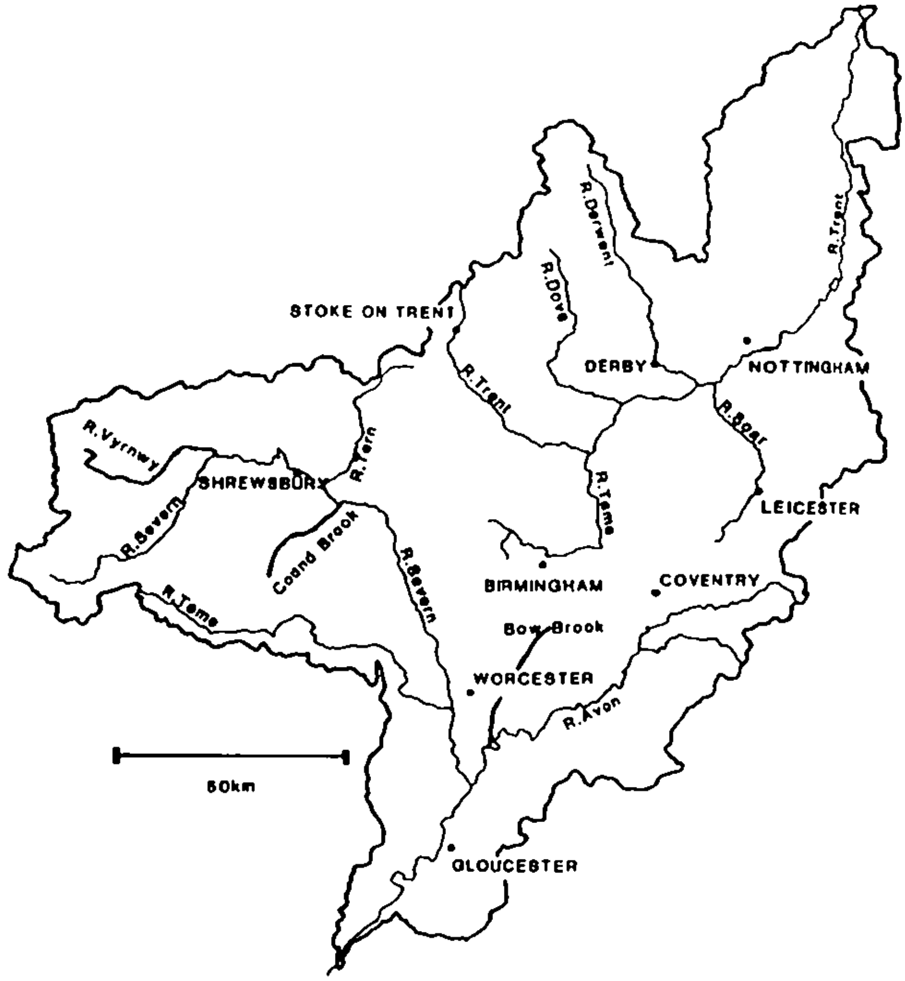

Figure 1.2 *The position of the rivers under assessment within NRA Severn Trent Region*

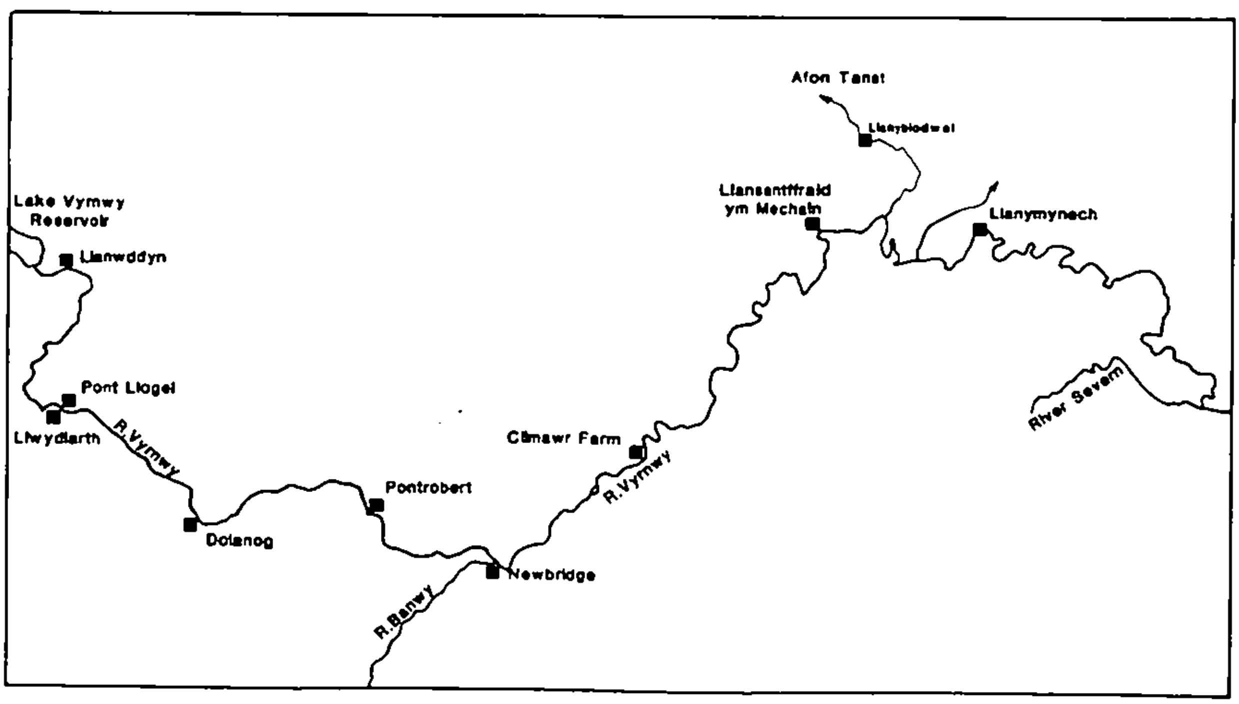

Figure 1.3 *The River Vyrnwy*

1.3 THE COUND BROOK

The Cound Brook lies to the south/south east of Shrewsbury, with the area under consideration being between Dorrington (SJ482034) and the confluence of the Cound and the River Severn (SJ566062) as shown in Figure 1.4. Within this area, the river flows are affected by abstractions, mainly for spray irrigation, which take place in the summer months from May to the end of August. Since there is no permanent gauging structure on the Cound itself the control of most of the abstraction licences is based on data from the Hookagate flow gauging station (NRA No. 2018) situated on the Rea Brook. The Rea Brook catchment is of similar size and character to the Cound, but the use of this data has been bought into question due to the effect of discharges of sewage effluent on flows in the Rea. A schematic diagram of the position of the abstractions on the Cound Brook is given in Figure 1.5 along with abstraction levels in Table 1.1. The largest licensed abstraction levels are found in the area between Condover (SJ497055) and Upper Cound (SJ553050) (licence Nos. 485 and 520). The upstream limit of the abstractions is, as indicated above, at Dorrington and there are no perceived problems with water quality within the area of the Cound in question.

The perceived fisheries impact of the abstractions is on fry/juvenile and adult brown trout, with the summer abstractions having most impact between April and September. The area of highest fisheries value lies between Condover and Eaton Mascott (SJ534055). The impacted area extends to the Coundmoor Brook, a tributary of the Cound (it flows into the Cound at SJ055052), which has two additional abstraction points within its course.

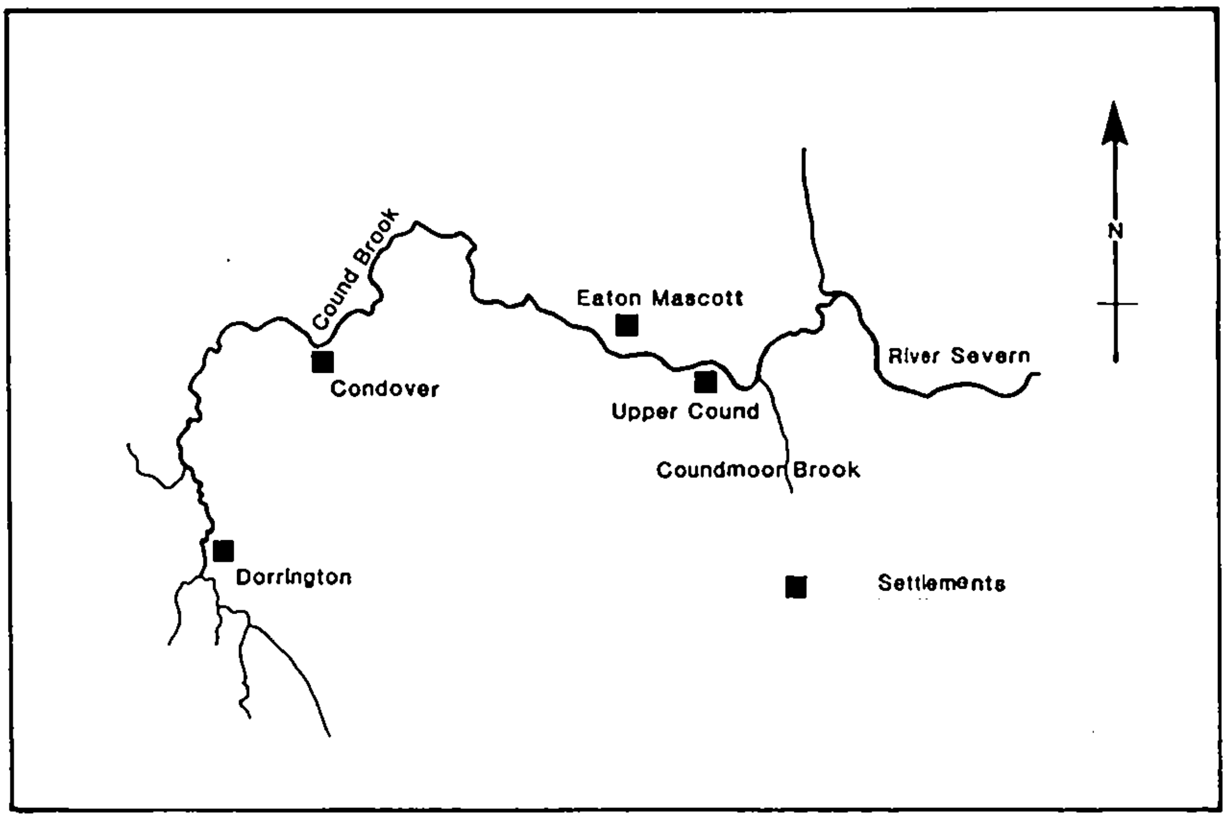

Figure 1.4 The Cound Brook

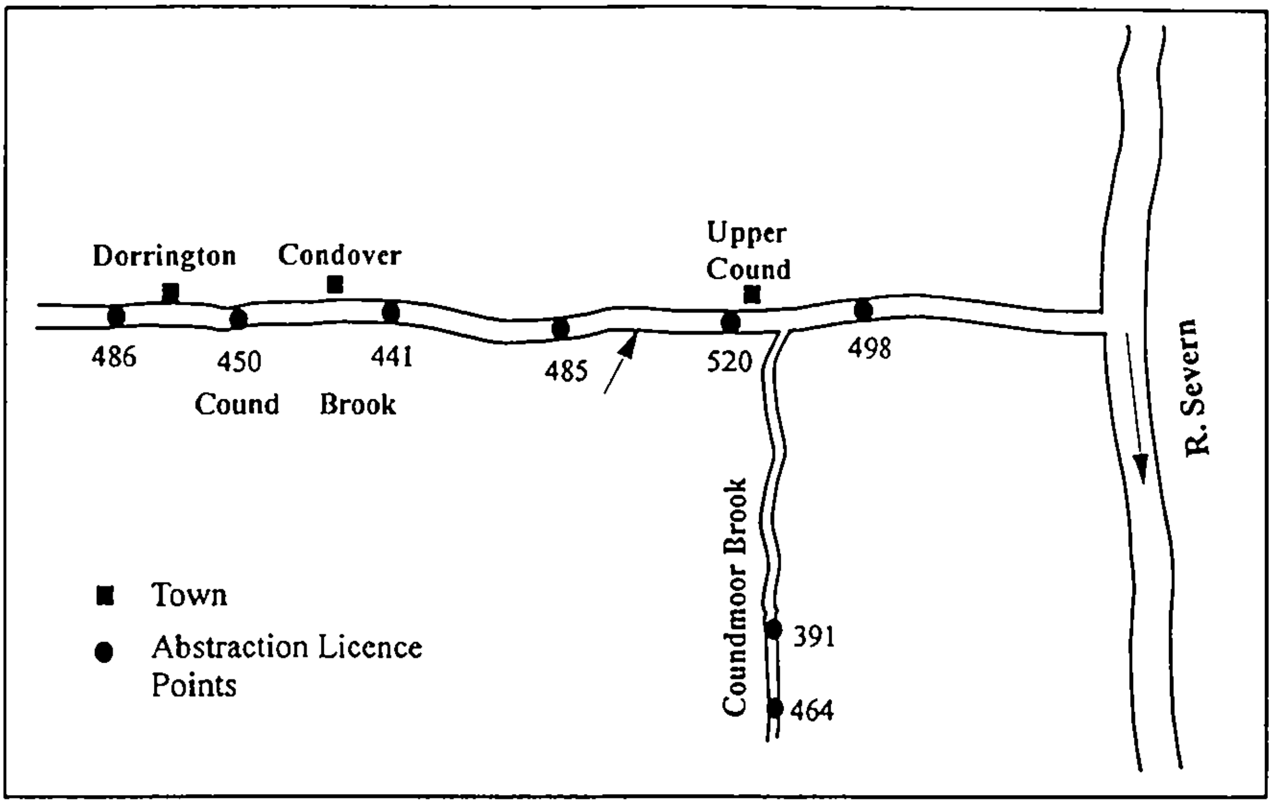

Figure 1.5 *Schematic diagram of the Cound Brook abstractions*

Table 1.1 *Cound Brook: Levels of abstraction per licence*

Licence No.	NGR.	QD Mld	QA Mla	Comments:
486	SJ 481023	0.192	4.545	Controlled by 18 Mld at Hookagate
450	SJ 480038	0.509	36.364	Local control Q > 10 Mld
441	SJ 498057	0.614	18.493	Controlled by 18 Mld at Hookagate
485	SJ 503060	1.502	59.582	Controlled by 18 Mld at Hookagate
520	SJ 545052	1.23	41.0	Controlled by 23 Mld at Hookagate
464	SJ 553020	0.455	11.366	Local control Q > 1.56 Mld
391	SJ 552031	0.308	10.91	Local control Q > 1.5 Mld
498	SJ 556053	0.64	7.67	Controlled by 23 Mld at Hookagate

1.4 THE BOW BROOK

The Bow Brook is situated to the south west of Redditch. The whole of the Bow Brook channel is under consideration here, from its confluence with the River Avon near Defford (at SO920425) to its headwaters near Redditch, as shown in Figure 1.6. There are a number of abstractions from the Bow itself and also from groundwater within the Bow catchment, as shown in the schematic diagram in Figure 1.7. The main groundwater abstractions take place in the headwaters of the catchment, in particular at Webheath (SP010669). In the lower area of the catchment there are a large number of direct abstractions for spray irrigation. These are controlled via the sole gauging station on the Bow at Besford Bridge (No. 054015). The levels of abstraction per licence are listed in Table 1.2 below.

The probable impact of the abstraction from groundwater in the headwaters of the catchment is that it may result in low summer flows in the headwaters of the river (above Priests Bridge (SO989598)). These low flows could, however, also be due to faster runoff in this part of the catchment as a result of urbanisation in the Redditch area. The resulting loss of summer flows is reduced in the area below Priests Bridge due to discharges from a water reclamation works. The lower part of the catchment is impacted by abstractions for spray irrigation with a perceived reduction in of summer flows. The level of these has been frozen with any new licences being winter pump-storage abstractions only. Additionally, there is a second discharge from a sewage treatment works at Crowle (SO935557).

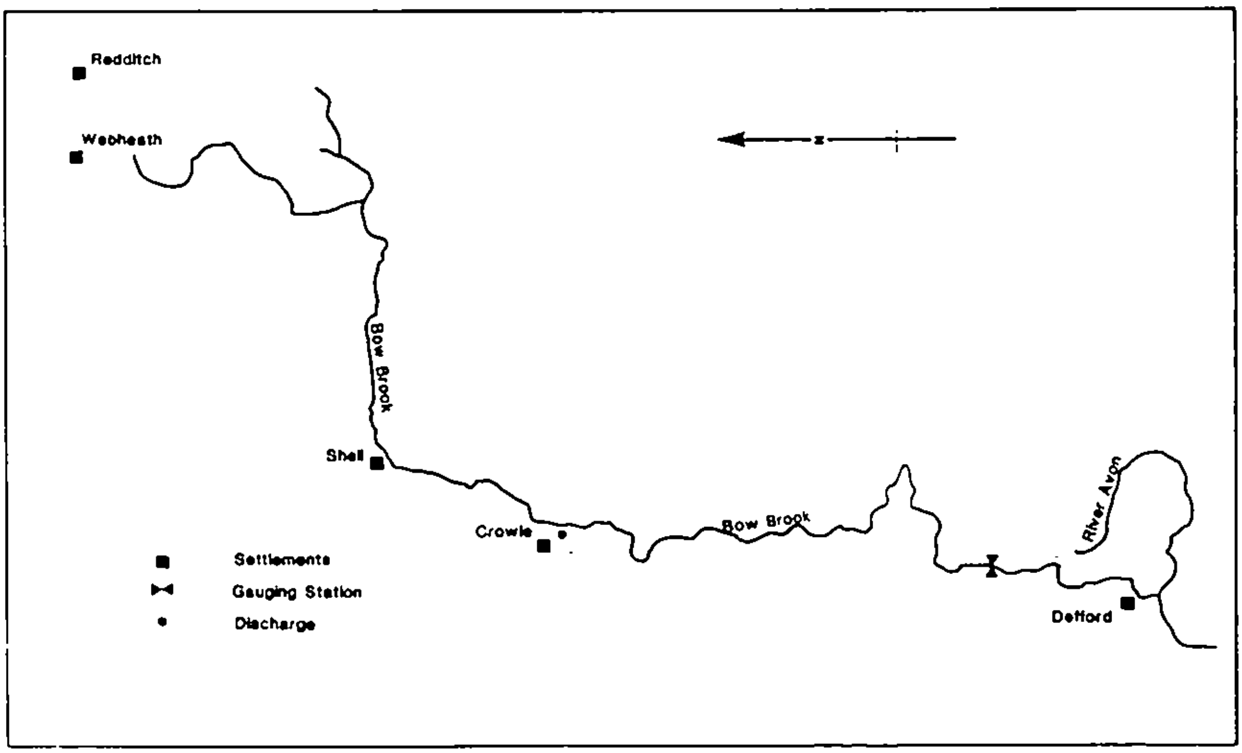

Figure 1.6 The Bow Brook

Table 1.2 Bow Brook: Levels of abstraction per licence

Licence No.	NGR.	Control Station.	Annual Q (m3)	Comments:
0024	SO 9225 4465	Besford Bridge	56825.000	-3
0025	SO 9225 4315	Besford Bridge	1227.420	-2
0045	SO 9225 5505	Besford Bridge	4546.000 / 13638.000	-3
0048	SO 9475 4845	Besford Bridge	15911.000 / 455.000	-3 / -3
0049	SO 9485 4815	Besford Bridge	186386.000	-2
0050	SO 9337 4740	Besford Bridge	2273.000	-3
0051	SO 9435 4875	Besford Bridge	3273.120	-2
0059	SO 9805 6155	Besford Bridge	4200.504	-2
0062	SO 9255 4355	Besford Bridge	781.912	-2
0066	SO 9485 4835	Besford Bridge	2727.600	-2
0071	SO 9255 4475	Besford Bridge	3636.800	-2
0098	SO 9243 4339	Besford Bridge	9092.000	-2
0106	SO 9665 6425	Besford Bridge	18184.000	-3
0112	SO 9205 4275	Besford Bridge	8728.320 / 363.680	-2
0116	SO 9195 4285	Besford Bridge	18184.000	-3
0118	SO 9075 5185	Besford Bridge	27276.000	-3
0119	SO 9425 6115	Besford Bridge	6819.000	-3
0127	SO 9785 6125	Besford Bridge	1599.965	-3
0129	SO 9405 4795	Besford Bridge	4546.000	-3
0130	SO 9865 5985	Besford Bridge	10000.000	-3
0133	SO 9325 5305	Besford Bridge	13638.000	-3
0134	SO 9235 4665	Besford Bridge	25920.000 / 27276.000	-3
0135	SO 9415 4865	Besford Bridge	18184.000	-3
0136	SO 9425 4875	Besford Bridge	9092.000	-3
0138	SO 9255 4605	Besford Bridge	4217.001	-3
0139	SO 9365 4735	Besford Bridge	16444.000 / 9090.000	-2
0140	SO 9315 5425	Besford Bridge	20000.000	-3
0143	SO 0060 6530	Besford Bridge	0.000 (Unknown?)	-1

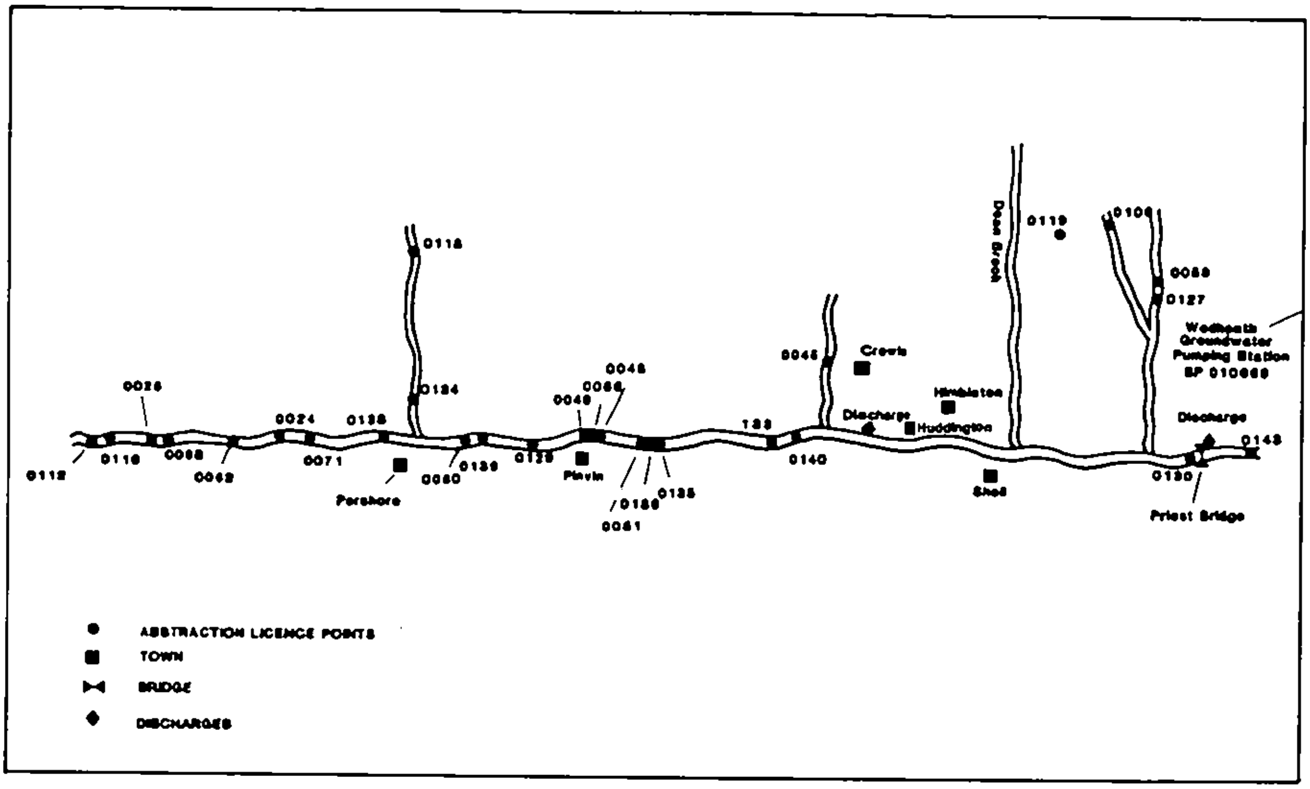

Figure 1.7 *Schematic diagram of Bow Brook abstractions*

The Bow Brook is perceived as being one of the highest conservation value brooks in the region. The fishery contains brown trout (being the species of main interest here), with coarse fish being found as far upstream as Shell (SO952596). Thus the impact of the summer reduction in flows is likely to be a loss of fry/juvenile and adult trout habitat, with possible losses in habitat for coarse fish in the lower parts of the river. An additional problem for angling is that of weed growth with extreme amounts of instream vegetation being found in areas of the brook downstream of Shell. The cause of this is not clear since it could be related to the water quality/nutrient load of the river or due to the climate of recent years. Some concern has also been expressed that water quality may also have an impact on fish populations during summer low flow periods.

1.5 EXISTING ENVIRONMENTAL IMPACT DATABASES

For each of the three study catchments the availability of environmental impact data is summarised in Table 1.3 below.

Table 1.3 *Sources of information and further detail*

Data	Cound Brook	Vyrnwy	Bow Brook
Catchment Management Plan	1997	1995	1994
Spot gaugings	✓	✓	✓
Flow measurement	x	✓	✓
Fishery survey	✓	✓	✓
Biological survey	✓	✓	✓
River corridor survey	x	✓	✓
WQ monitoring data	✓	✓	✓

2 Assessment of suitability of selected rivers for IFIM study and selection of study reaches

2.1 METHODOLOGY

The three rivers concerned were assessed for their suitability as IFIM/PHABSIM study sites through a combination of field surveys and an examination of the available information/data sources for each of the three catchments. The field survey work consisted of a visual examination of the channel characteristics and habitat types within selected reaches along each of the rivers. The potential of individual reaches for IFIM study was determined through an assessment of how well the habitats available within the reach represent the larger areas of the river in question. Additionally, the practical aspects of carrying out the data collection procedures necessary to calibrate the PHABSIM models were also taken into consideration. A summary of the assessment for each of the three rivers is presented below.

2.2 THE RIVER VYRNWY

A total of ten sites were examined on the river Vyrnwy and their position is illustrated in Figure 2.1. Within the area of the river under consideration, it was apparent that there was a large change in the habitat types in the reach between Pontrobert and the confluence of the Vyrnwy with the Banwy at Newbridge, where the river becomes much larger and appears to have a much reduced slope. This change coincides with the change in fishery with coarse fish (eg: chub) being found downstream of Newbridge. As a result, two potential study sites were selected which would then allow either, or both, of these zones to be represented, as necessary, in subsequent studies.

In the zone between Lake Vyrnwy reservoir and Pontrobert the target species of interest are brown trout, with salmon also occuring downstream of Dolanog, as outlined in Chapter 1. In this area the change in flow regime may be expected to have the largest impact since the relative change in flow will be reduced downstream of the confluence with the River Banwy (a major tributary of the Vyrnwy joining the river at Newbridge (SJ143114)) and with the subsequent input from other rivers further downstream. Within this zone the river ranges from being 5-10m wide at the upstream end of the zone, to approximately 20m wide at the downstream end. The main habitat types found were runs (by far the most common type of habitat, ranging in depth, at the time of survey, from 20-30cm to 1m), riffles/rapids and pools. The substrate consists of cobbles and coarse gravels with some boulders and outcrops of bedrock in areas of riffle/rapid habitat. In general, only small amounts of instream vegetation are found (if at all) and the river is frequently shaded by riparian trees.

The most suitable study site for an IFIM survey within the upstream zone is site 2 (in the area of grid ref. SJ016166). This site forms a good representative reach with the main habitat types available in the zone under consideration being well represented within a 200-300m long stretch of river. The distribution of habitat types is dominated by runs (as in the whole of this upper zone) with the rest of the habitat consisting of pools and riffle/rapids.

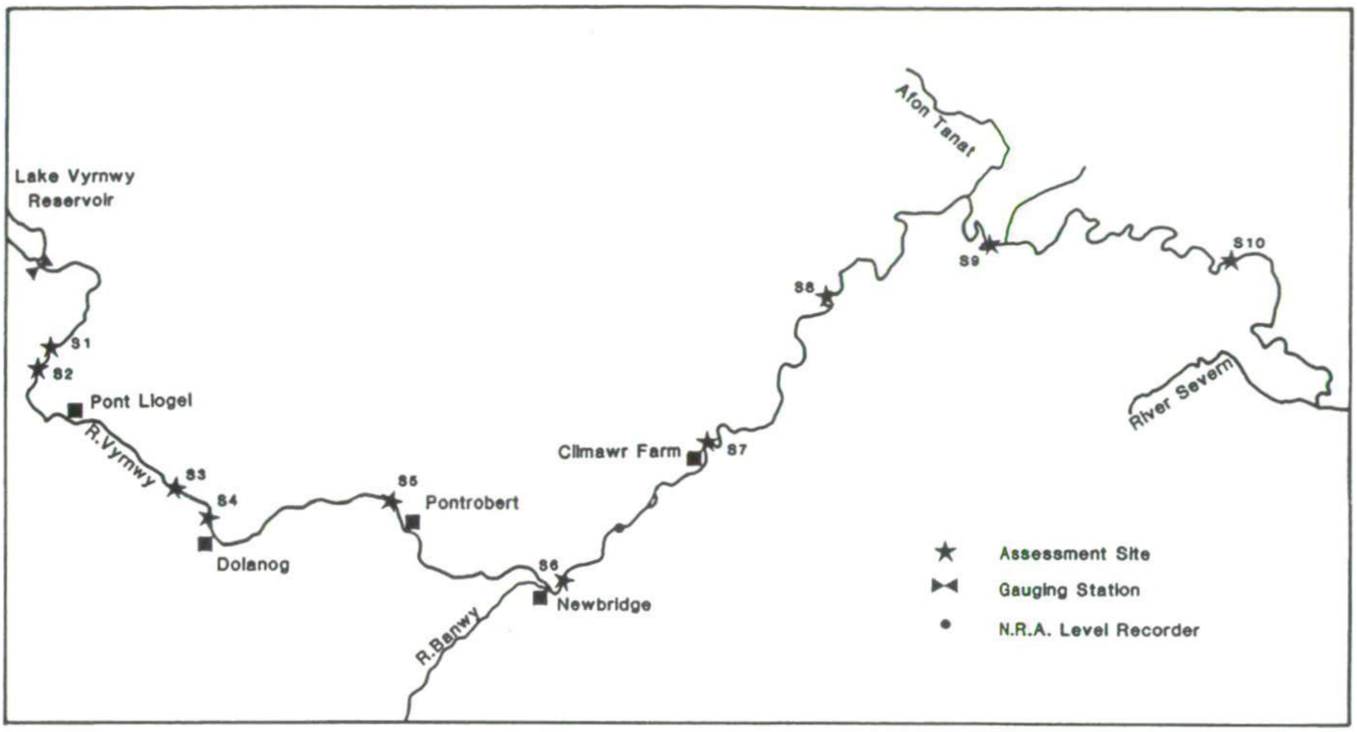

Figure 2.1 *River Vyrnwy: Position of assessment sites*

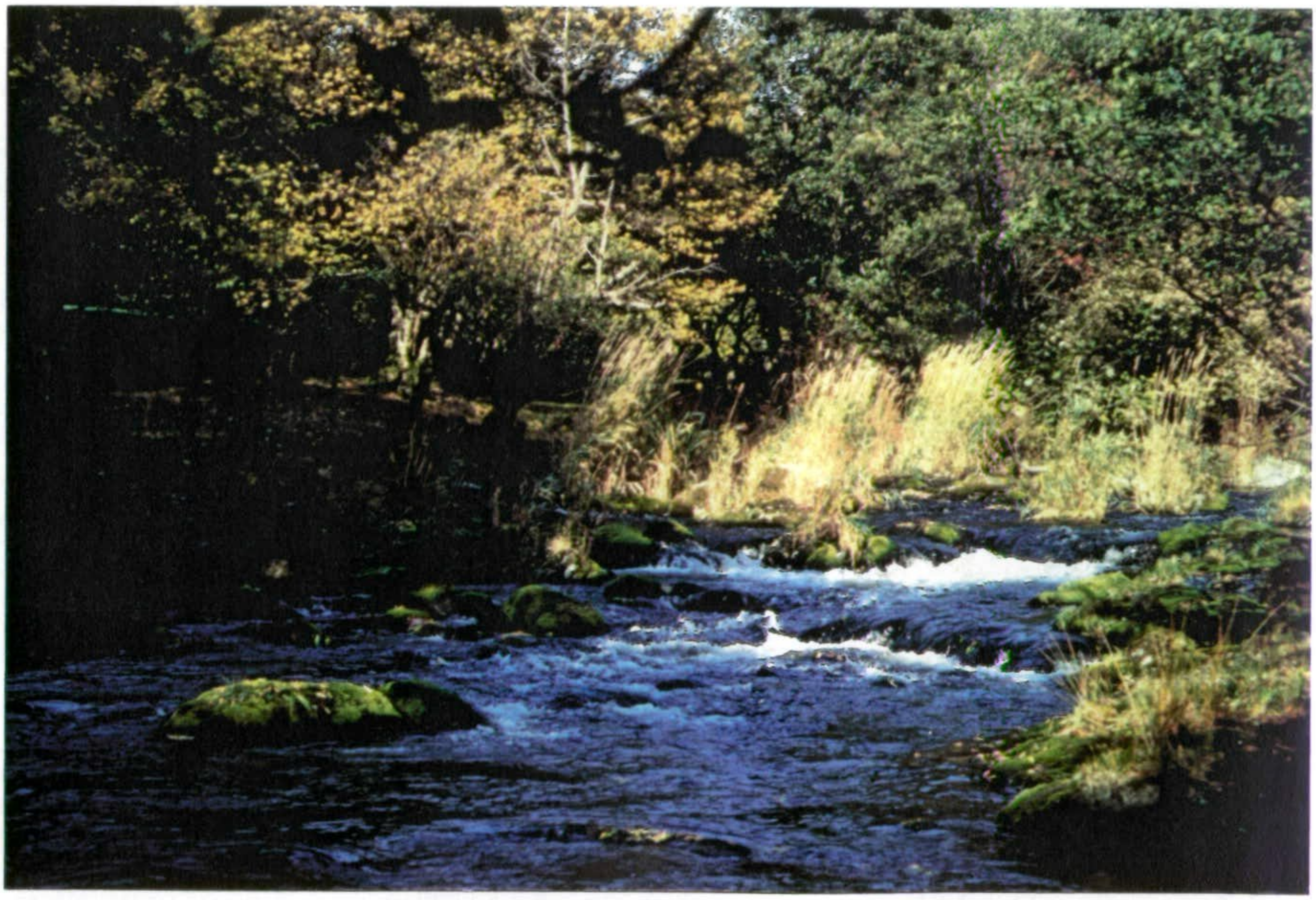

Figure 2.2 *R. Vyrnwy site 2: Riffle/rapid habitat*

Figure 2.2 displays a photograph of the downstream end of the proposed study reach illustrating the riffle/rapid types of habitat. Figure 2.3 shows the deeper run and pool habitat found within the reach. Moving upstream through the reach, there is then a succession of riffles and runs, as shown in Figure 2.4, and the river also becomes braided. The upstream end of the site is characterised by a further succession of shallow runs and riffles as displayed in Figure 2.5. Although the site is above Dolanog and as a result 'wild' salmon are not found in the reach, this is due to a natural barrier rather than lack of habitat as demonstrated by the occurrence of stocked fish. Thus, it would be possible to make an assessment of the likely impact of the changes in flow regime on salmon as well as trout.

In the second, downstream zone the river varies from being 20m wide (approx) below Pontrobert to approximately 40m wide towards its confluence with the River Severn. The river shows a marked increase in size below its confluence with the Banwy, at Newbridge, as shown by the contrast between Figures 2.6 and 2.7 with the former showing the Vyrnwy just upstream of the confluence and the latter showing the river at Meifod (SJ157128). In relative terms the impact of the proposed change in flow regime on summer flows will be reduced below Newbridge due to the contribution of flows from the R. Banwy. This suggests that any impact on habitat may also be lessened downstream of this point. Fisheries surveys show that coarse fish such as chub are found as far upstream as Newbridge and hence a site chosen between Newbridge and Llansantfraid would allow the study of chub as well as salmon and trout since they are all found within this area. Downstream of Newbridge the river habitats are less diverse than in the upstream zone, mainly consisting of deep runs or glides and gravel bars/riffles with some pools occurring mainly on the outside of meander bends. The substrate found in this area tends to be finer than that in the upstream zone, consisting mainly of gravels with some silt, cobbles and boulders.

The size of the river below Newbridge becomes a limiting factor in terms of the practicality of the collection of PHABSIM calibration data. This is due to the need to use a boat (as indicated in the fish survey results for this area) when collecting the data and the consequent increase in the time taken to carry out each survey. This is balanced by the reduction in habitat diversity within the area and hence it would be possible to reduce the number of survey transects accordingly. The most suitable site for an IFIM study within this zone is site 8 (upstream of Cilmawr Farm SJ182148), where the river is at the upper size limit of practical application of the model with current methods of data collection. Here the river is up to 30m wide (approx) and the types of habitat available within this zone are well represented in a relatively short reach of river. Figure 2.8 gives examples of a gravel bar and pool habitats, in this case associated with a meander in the river. As outlined above, the most common type of habitat is the glide or deep run and an example of this, within the proposed study reach, is shown in Figure 2.9.

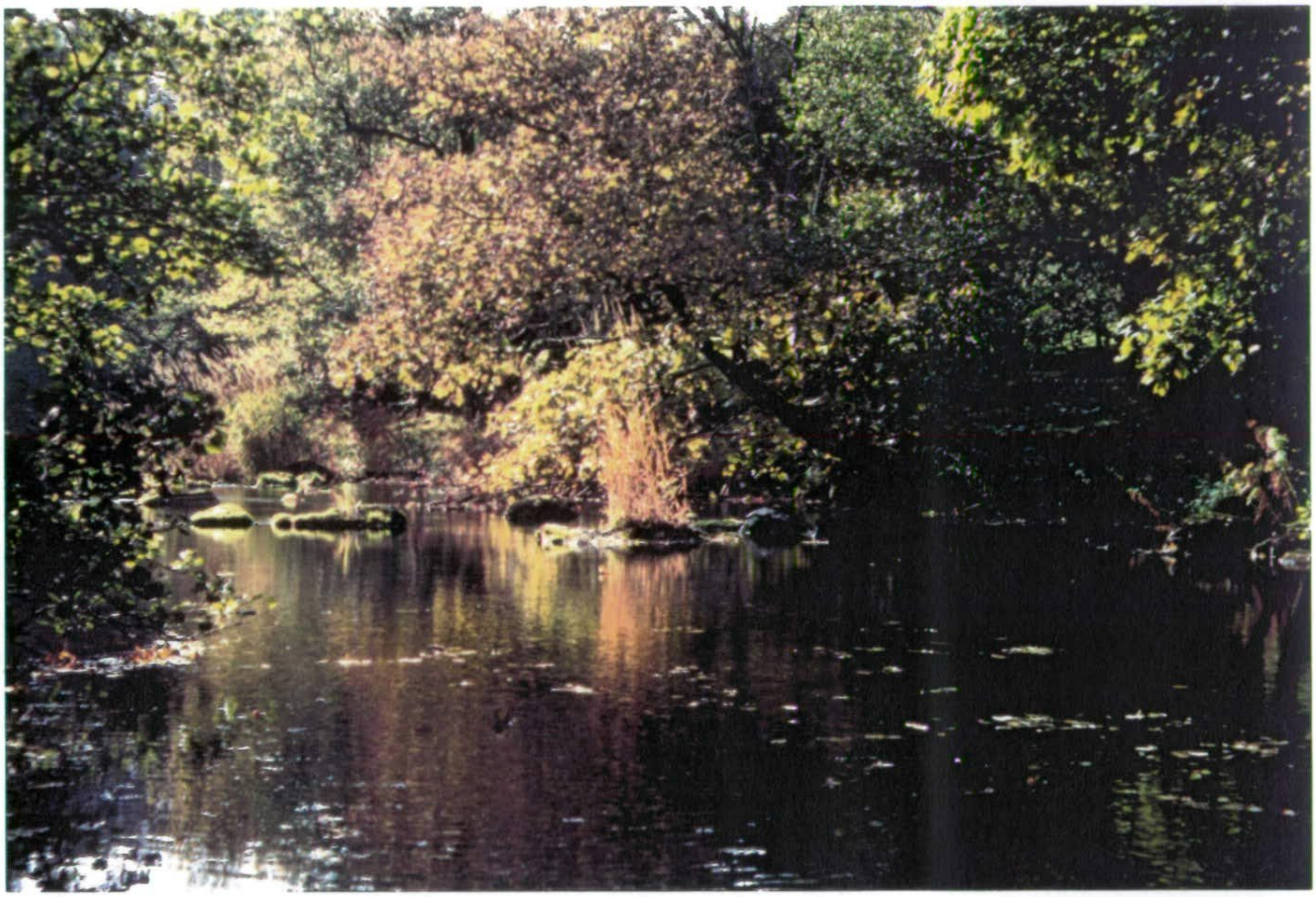

Figure 2.3 *R. Vyrnwy site 2: Pool and deep run habitats*

Figure 2.4 *R. Vyrnwy site 2: Riffle and run habitats*

Figure 2.5 *R. Vyrnwy site 2: riffle and shallow run habitats*

Figure 2.6 *R. Vyrnwy: Upstream of confluence with R. Banwy at Newbridge*

Figure 2.7 *R.Vyrnwy: D/S of confluence with the R. Banwy at Meiford*

Figure 2.8 *R. Vyrnwy site 8: Gravel bar and pool habitats*

Figure 2.9 *R. Vyrnwy at site 8: Deep run/glide habitat*

2.3 The Cound Brook

The Cound Brook was assessed at a total of seven sites, the position of which are illustrated in Figure 2.10. Within the area of interest, between Dorrington and the confluence with the River Severn the river ranges from being 5m wide up to approximately 10m. The general pattern of habitat types consists of sequences of riffles, pools and runs, as shown in Figure 2.11, with the substrate being mainly gravel and cobbles with some sand. In the areas where the banks of the brook have no woody vegetation the river widens and the habitat is mostly riffle and runs, illustrated in Figure 2.12.

The most suitable site for IFIM study is site 6, located approximately 100m downstream of Cantalop Bridge (SJ518062). Within this reach there is a good succession of habitats including runs, pools and riffles along with gravel bars and meander bends in the river. Additionally, the river banks are only partially forested in this area and thus samples of the habitats associated with both wooded and clear riparian zones may be found. This site has a further benefit in that it lies within the area of highest fisheries value. It is also downstream of the largest abstraction (licence number 485) within the catchment and hence, the impact on the flow regime of the river at this point should be relatively large.

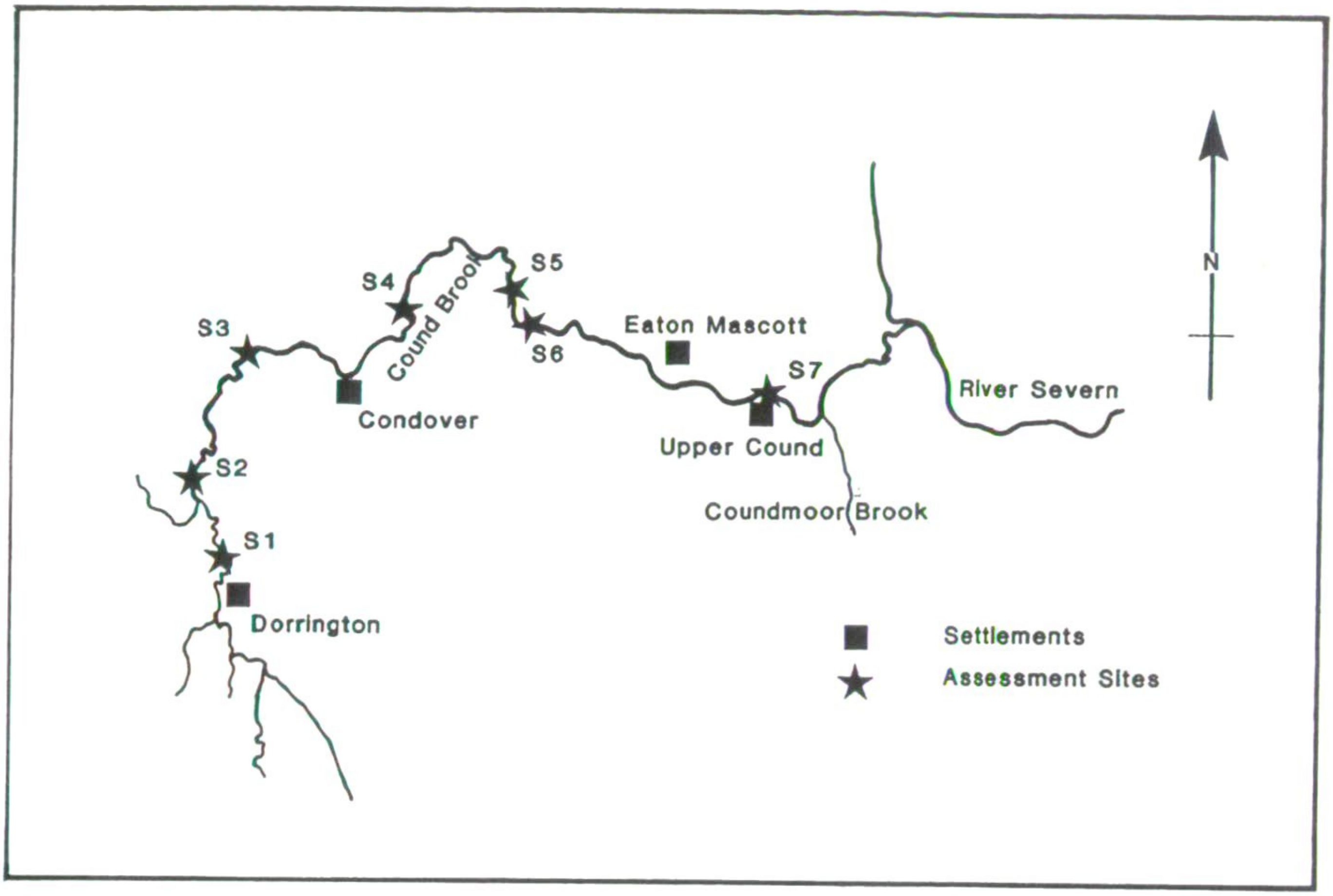

Figure 2.10 *Cound Brook: Position of assessment sites*

Figure 2.11 *Cound Brook: Riffle, pool and run habitats*

Figure 2.12 *Cound Brook: Riffle and run habitat*

2.4 THE BOW BROOK

The Bow was assessed at a total of eight sites, as detailed in Figure 2.13. The site visits revealed a distinct change in the character of the river downstream of the outfall at Crowle. Vegetation levels increase dramatically within a short distance below the sewage works, perhaps as a result of high levels of nutrients coming from the outfall. Below the Crowle outfall the channel was choked with vegetation profoundly influencing the available depths and velocities. This secondary influence upon physical habitat availability overshadows any primary impact upon depths and velocities by reductions in flow due to abstraction. IFIM study is not recommended until water quality/vegetation related issues are investigated further. The high levels of macrophyte growth present below Crowle (shown in Figure 2.14) also mean that it would, in any case, be impossible to obtain the hydraulic calibration data necessary to produce the PHABSIM flow simulations for habitat modelling. Consequently, we do not recommend carrying out an IFIM study in the area of the river between Crowle and the River Avon under present conditions. This study has therefore concentrated on selecting potential study sites upstream of Crowle, which represent the upper part of the river where levels of macrophyte growth are more natural and availability of fish habitat appears to be controlled by flow to a much greater extent.

The most suitable study reach within the area of the Bow above Crowle is site 6 at Huddington (SO944573). This reach contains a range of habitat types representative of this portion of the river, with riffle and run sections (Figure 2.15), areas of deeper runs and pools

(Figure 2.16) and areas where moderate amounts of instream vegetation occur (Figure 2.17). Again, these habitat types are all found within a reasonably short length of river, assisting any potential study. Although representative of the zone upstream of Crowle the recommended study reach lies above the area of river where most of the spray irrigation abstractions occur and as a result the impact on summer low flows may not be at its maximum. Again, we do not recommend IFIM study in this upstream zone until further investigation of water quality related issues in the downstream zone where abstractions impact flows to a greater extent.

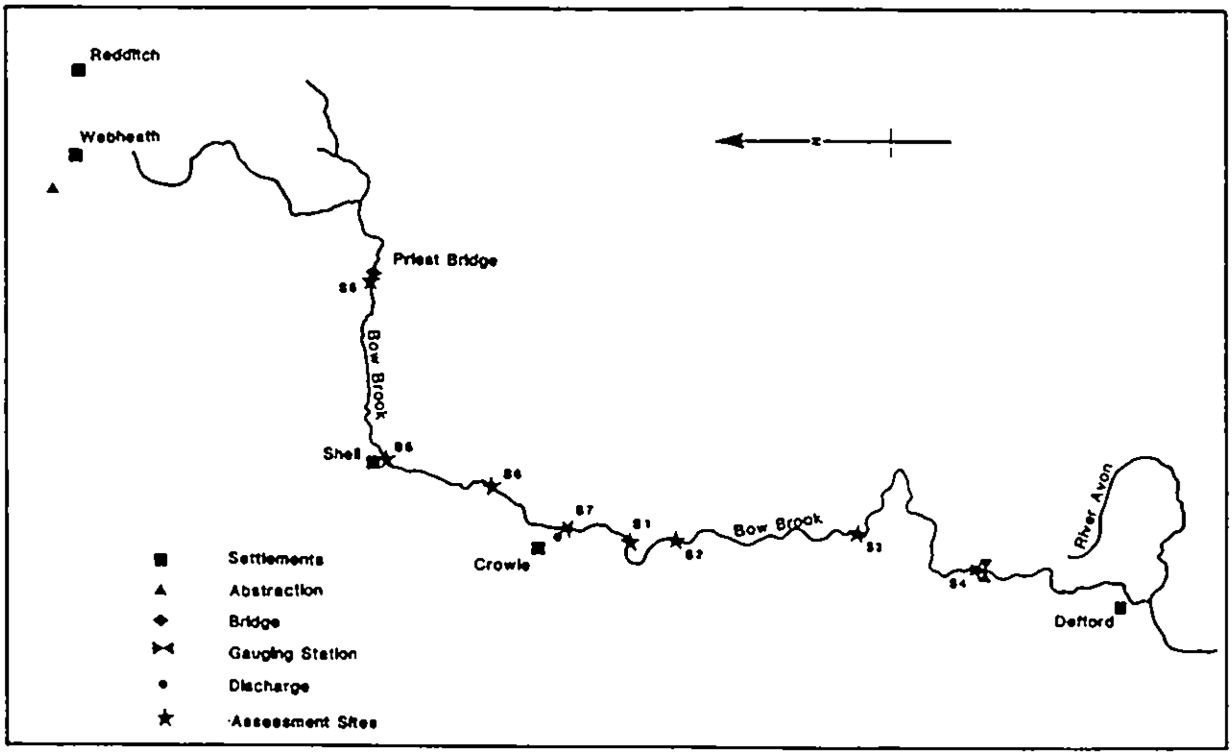

Figure 2.13 *Bow Brook: Position of assessment sites*

Figure 2.14 *Bow Brook: D/S of Crowle showing extreme levels of macrophyte growth*

Figure 2.15 *Bow Brook site 6: Riffle and run habitat*

Figure 2.16 *Bow Brook site 6: Deep run and pool habitat*

Figure 2.17 *Bow Brook site 6: Riffle habitat with some macrophyte growth*

3 Data requirements for IFIM studies

3.1 FIELD SURVEY DATA REQUIREMENTS

Details of the calibration data required by the PHABSIM system are given in "Data requirements and collection procedures for application of the Instream Flow Incremental Methodology in the UK" (Johnson *et al* (1991) (updated 1994)). We recommend that any field data collection programme carried out on the sites detailed above should be carried out as described in the above guide. The guide provides information on transect selection within a representative study reach. Based on the visual surveys carried out when assessing the rivers, we suggest that the upstream site on the Vyrnwy and the sites on the Cound and Bow brooks will require 10-12 study transects and the downstream site on the Vyrnwy will require up to 6 study transects.

3.2 HABITAT SUITABILITY DATA

The target species of most interest, as identified by NRA fisheries staff, are as shown in Table 3.1 below. The time period of maximum impact is the summer months (as detailed in Chapter 1) thus, the most important life-stages are fry (emergent) and juvenile salmonids and spawning chub.

Table 3.1 *Critical target species and life-stages for rivers under assessment.*

River	Target Species	Life Stage
R. Vyrnwy	Trout Salmon Chub	Fry, Juvenile & Adult Fry, Juvenile & Adult Spawning
Cound Brook	Trout	Fry, Juvenile & Adult
Bow Brook	Trout	Fry, Juvenile & Adult

PHABSIM modelling comprises two key elements, hydraulic simulation and then habitat simulation. Initially, the hydraulic model(s) within PHABSIM are calibrated using observed field data and then, for a range simulation discharges, values of mean column velocity, depth and substrate type are produced. The next stage in the simulation process is to assign each of the simulated values of depth, velocity and substrate a habitat suitability value between 0 and 1, describing their relative value to the particular target species life-stage. This produces an expression of available habitat, Weighted Usable Area (WUA), vs discharge for each target species life stage in question and is achieved within PHABSIM by the use of "Habitat Suitability Indices" (HSI). For each target species life-stage a HSI, in the form of a univariate curve taking values between 0 and 1, must be defined for each of the microhabitat variables velocity, depth and substrate.

Bovee (1986) defines three types of suitability index curves which may be used for IFIM simulations using PHABSIM. The distinction between the different types of habitat suitability criteria is in the way that they are derived. The three types are as follows:

Category I: The habitat criteria are derived from life history studies in the literature or from professional experience and judgement, and are based on the adjudged suitability of physical habitat variables for target species life-stages.

Category II: The habitat criteria are based on frequency analysis of microhabitat conditions utilised by different life-stages and species identified by field observations. These criteria are termed "habitat utilisation curves" because they depict the conditions that were being used when the species were observed. Utilisation functions may not always accurately describe a species' preference because the preferred physical conditions may be absent or limited at the time of observation.

Category III: These are Category II curves in which the criteria are corrected for bias by factoring out the influence of limited habitat availability. This correction is aimed at increasing the transferability of the criteria to streams that differ from those where the criteria were originally developed. Category III curves are referred to as "habitat preference curves". Habitat preference for values of a given microhabitat variable is defined as the ratio of habitat utilisation to habitat availability. In general, the greater the diversity of habitats present in the stream used for sampling, the closer together will be the Category II and III curves derived from the utilisation and availability data.

Category II or Category III habitat utilisation curves have not been developed specifically for any of the rivers under assessment here. At present the only such curves developed in the UK are those for life-stages of trout and salmon produced for use in Dorset chalk streams by NRA South Western Region. Since the rivers under examination in this study are not analogous to those studied by SW NRA, only Category I curves are available at present. These tend to be broad banded in order to enhance their transferability and hence may tend to underestimate any changes in habitat due to changes in flow.

Since it is a relatively simple task to carry out further habitat simulations using new suitability data once the PHABSIM hydraulic models have been calibrated we would recommend considering the use of Category I curves for preliminary assessments. Category I curves are available from a variety of sources including: Johnson *et al* (1993 (1)) (brown trout - all life-stages); Bullock *et al* (1991) (chub - all life-stages); Raleigh, Zuckerman and Nelson (1986) (Brown Trout - all life-stages); Heggenes (1990) (salmon parr and young of year). It is recommended that the fisheries officers concerned should assess the applicability of the Category I habitat suitability data available for the target species life-stages relevant to each of the rivers in question in the light of their local knowledge and the fisheries data available. Following this they should comment on their applicability, and the necessity for any further development of the data along the lines of the sampling programme carried out by SW NRA in view of the likely expense of such work and the amount of benefit gained by utilising the new data. The Category I curves referenced above are included in the Appendix.

An alternative approach would be to test the Category I curves available for the target species life-stages in question, following a technique recently developed by the U.S. Fish and Wildlife Service (Thomas and Bovee, 1993). The basis of this is to test (for each species life stage) the hypothesis that (i) 'optimal' habitats will be used more than 'suitable' habitats and (ii) 'suitable' habitats will be used more than 'unsuitable' habitat. The authors suggest that statistically valid tests of these can be achieved using significantly smaller data sets than those required to develop Category II habitat utilisation curves.

3.3 FLOW TIME SERIES DATA

In order to examine the impact of a change in flow regime upon the variation of habitat availability over time, it is necessary to combine the Weighted Usable Area (WUA) vs discharge outputs from the habitat models within PHABSIM with flow records for the rivers in question. For each site such an assessment will require a time series of natural flows (ie the flows prior to any change in flow regime or with the influence of abstractions removed) alongside a time series of flows which include the artificial influence. Both sets of flow data should be based over the same time period. The production of such information for the sites selected on the River Vyrnwy should be relatively simple since the proposed change in flow is easy to define and both sites are close to flow measurement structures (the upper site is close to the Vyrnwy reservoir gauging station and the lower is near the level recorder at Meiford), thus minimising the need for extrapolation of the flow data from gauging station to study site.

The case of the Cound Brook is, however, not so easy since there is no permanent flow measurement structure on the river. This problem could be resolved by utilising the data from the Hookagate gauging station on the Rea Brook, but as the transferability of this data has been questioned (as outlined in Chapter 1) this aspect of any potential study requires further examination (eg. it may also be possible to use estimated flow data).

As mentioned above, IFIM application on the Bow Brook is not recommended before further investigation of water quality related issues. If at any future time IFIM assessment were deemed appropriate, flow data from the gauging station at Besford could be extrapolated relatively easily up or downstream as required.

We recommend that these issues relating to flow data availability should be examined before any IFIM application and that the necessary sets of data are produced for the required months of interest. Flow records should be as long as possible, up to a maximum of ten years record for daily data or the complete record of monthly data.

4 Timetable and cost of proposed IFIM applications

4.1 TIMING OF IFIM STUDIES

As outlined in the introduction the most critical time period for perceived change in habitat availability is during the summer months for each of the cases considered here. It is important to ensure that the range of calibration flows measured will allow extrapolation to the maximum and minimum flows likely to be experienced within the summer period. As a guide, the US Fish and Wildlife Service recommend that the lowest simulated flow should be no less than 0.4 times the lowest measured calibration flow and that the highest simulation flow should be no more than 2.5 times the highest measured calibration flow (Milhous (1988)). Obviously, the exact timing of such surveys will be dependant to a large degree on the occurrence of rainfall within the study catchments, but a suggested time schedule would be to carry out the initial, main, site survey(s) in March-April aiming to measure a high (relative to the summer flows) calibration flow data set. This would then enable a repeat calibration flow targeted at low discharges to be carried out July-Sept, with calibration data for the intermediate flow being obtained either during the April-September period or after September as necessary. This process will require close liaison with the relevant NRA staff to determine river flow levels before site visits are made.

4.2 OUTLINE COST OF AN IFIM/PHABSIM APPLICATION

A guide to the cost of an IFIM/PHABSIM application, in man days, is given below (note costs do not include travelling time):

Table 4.1 *Cost of IFIM study per site in man days*

Task	No. of staff required	No. of days per person
Initial site survey	4	4
Repeat calibration flow measurement	4	2
Data processing and checking	2	2
Model calibration and simulation	2	5
Report Production	2	5

Note, the above are costs per site. It is expected that the cost for each of the sites will be similar despite the large size of the lower site on the R. Vyrnwy since it will require fewer study transects as outlined above.

5 Conclusions and Recommendations

On the basis of the data examined, and visual surveys of river habitat types we recommend that IFIM studies are appropriate for investigation of the perceived problems on the R. Vyrnwy and the Cound Brook. We recommend that the Vyrnwy should be considered as two zones and have identified potential IFIM study reaches to represent each zone. For the Cound Brook we recommend a single representative IFIM study reach. Guides to habitat types present and recommended numbers of transects have been given for each study reach.

The portion of the Bow Brook most impacted by abstraction does not lend itself to IFIM application. It is clear that high levels of instream vegetation, probably associated with water quality issues (particularly the outfall at Crowle), play a major role in controlling depth and velocity availabilities. Since in applying the IFIM we assume that depth and velocity availability is controlled by flow, we conclude that IFIM is not appropriate in this case. Once water quality issues have been re-examined it may be appropriate to reconsider IFIM application if there is still a perceived problem associated with abstraction.

The critical target species and life-stages for the rivers in question have been identified as trout (fry, juvenile and adult), salmon (fry & juvenile) and chub (spawning). Category I habitat suitability data is available for these species life-stages and it is recommended that the fisheries officers concerned should assess the curves as discussed in Chapter 3 above. Also discussed in Chapter 3 is the need for time series data to carry out assessments of changes in habitat with the proposed/artificially influenced flow regimes and again it is recommended that this data is produced as discussed for each of the sites.

6 References

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Milhous, R.T. 1988. Hydraulics for physical habitat studies of streams. Instream Flow Information Paper No. 19. U.S. Fish & Wildlife Service Biological Report 88.

Appendix Category I Habitat suitabilty data

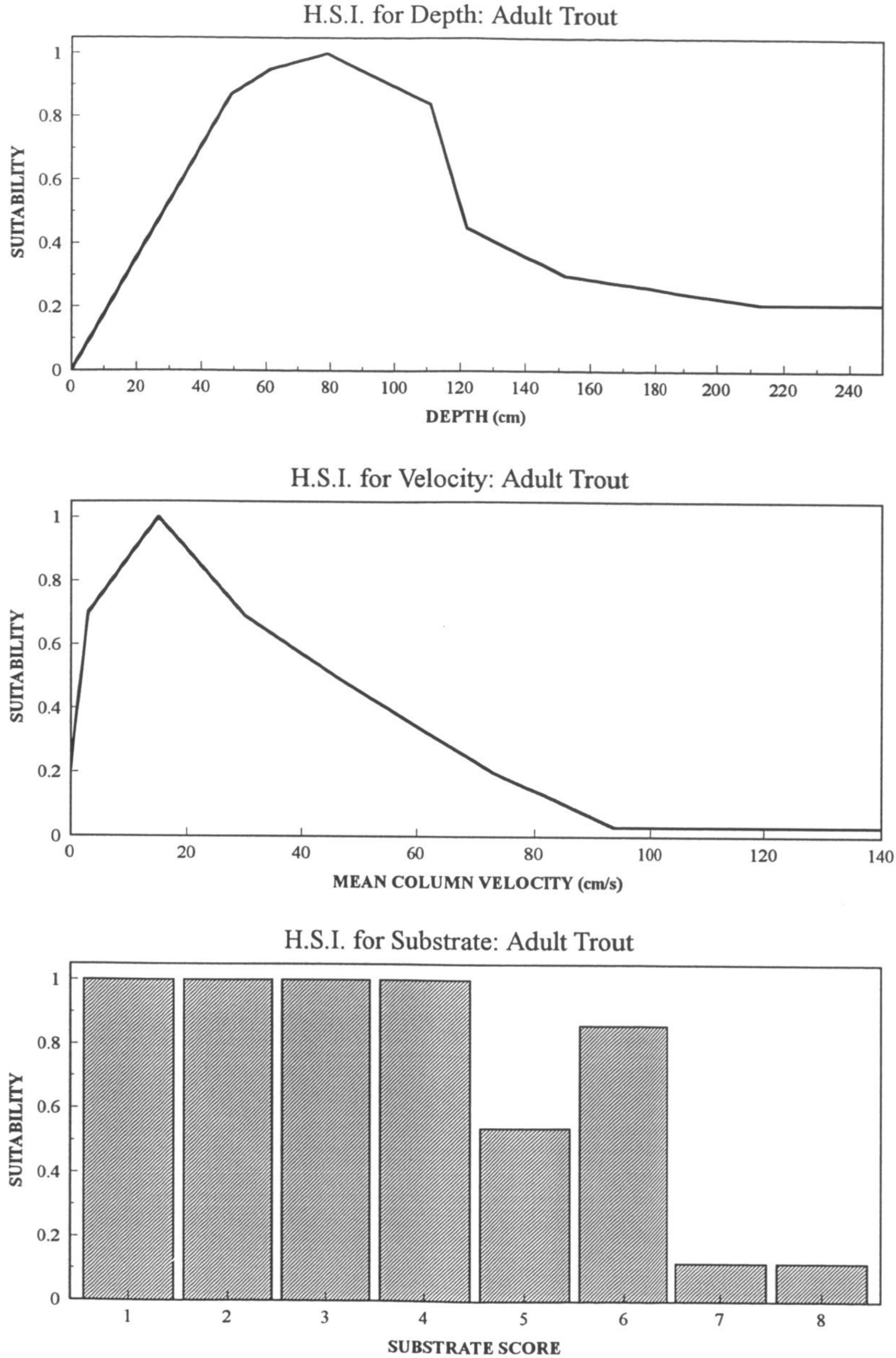


Figure A1 *Category I Habitat Suitability Indices: Adult Brown Trout. (Source: Raleigh & Zuckerman (1982))*

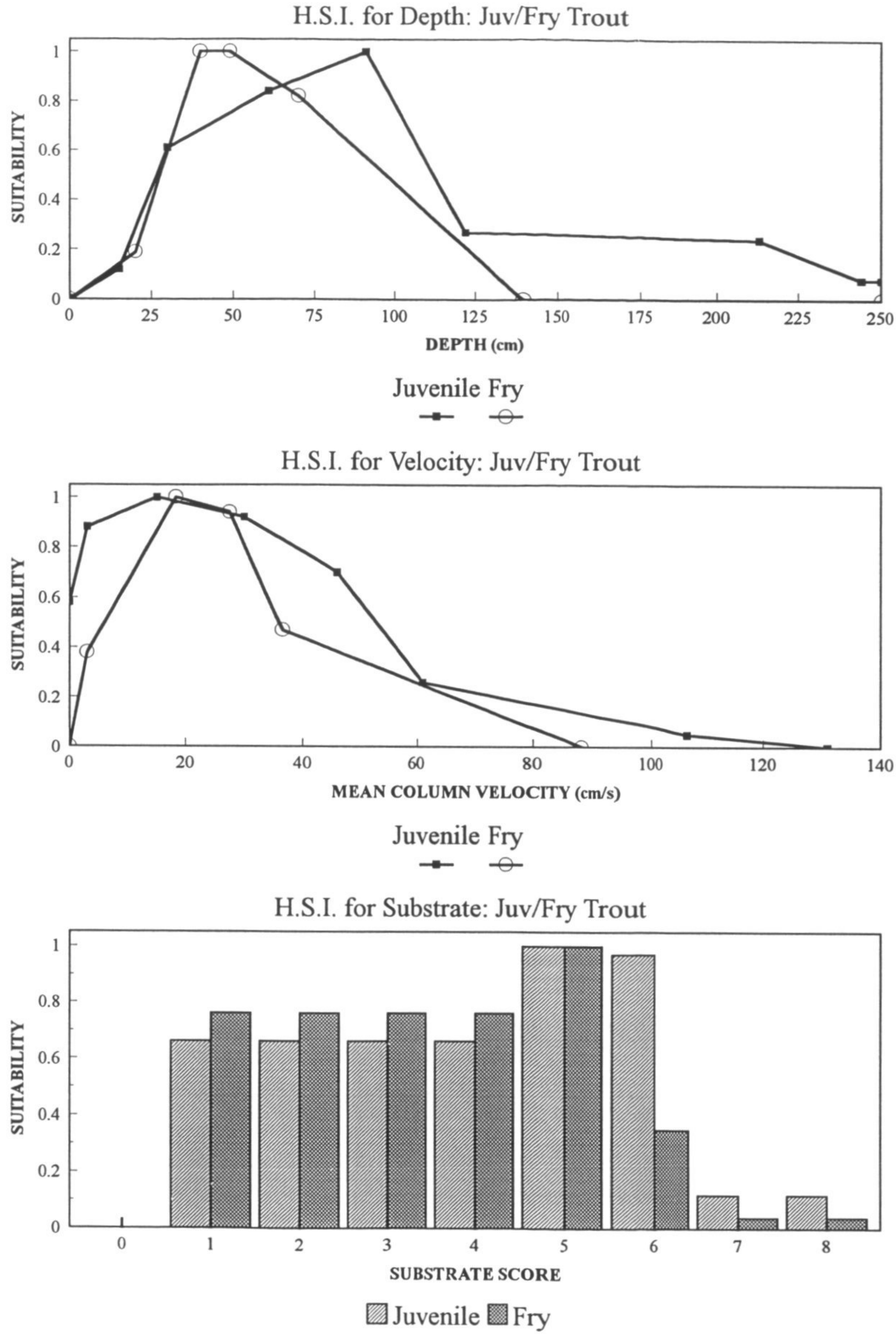


Figure A2 *Category I Habitat Suitability Indices: Fry and Juvenile Brown Trout. (Source: Raleigh & Zuckerman (1982))*

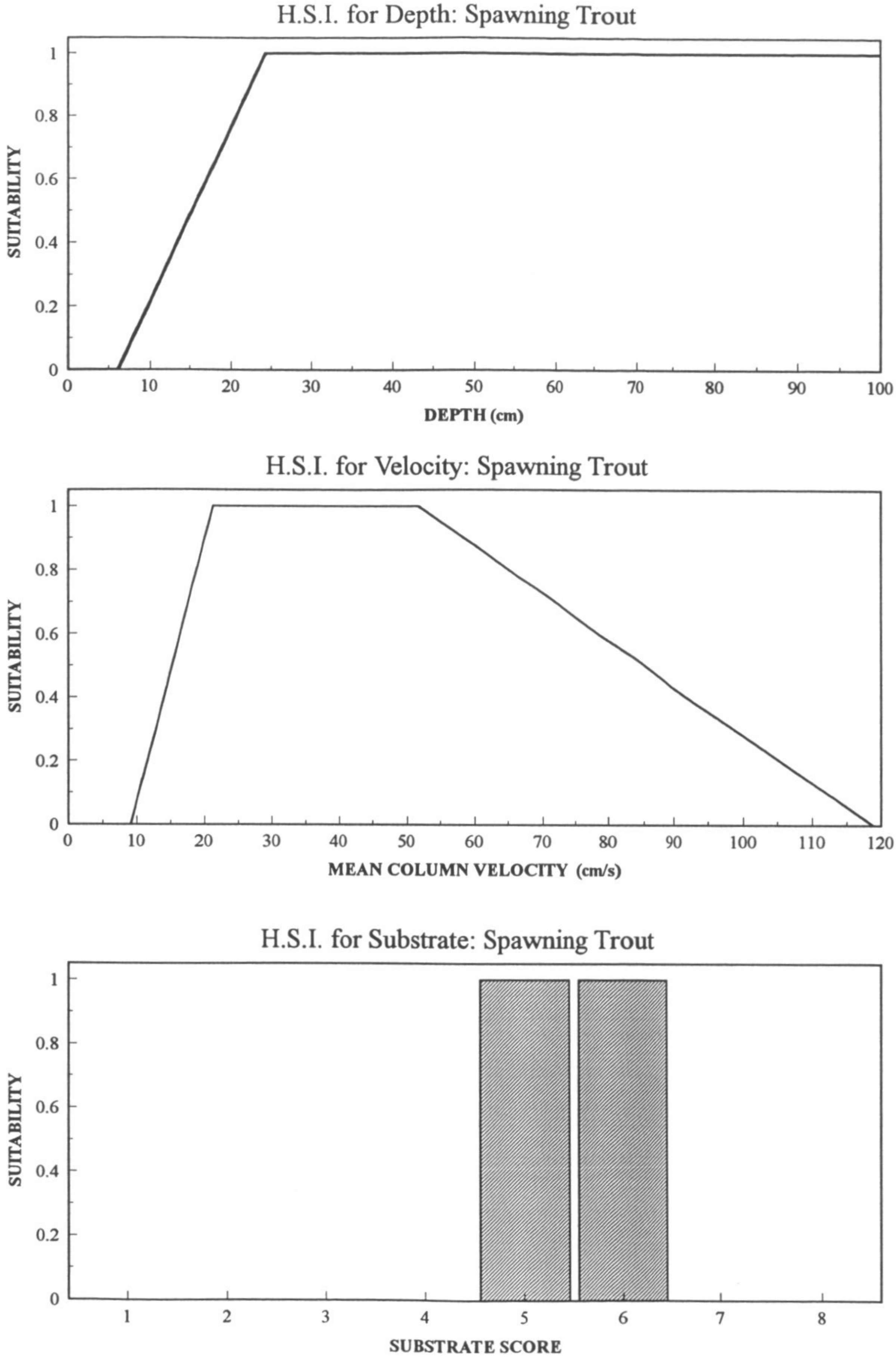


Figure A3 *Category I Habitat Suitability Indices: Spawing Brown Trout. (Source: Raleigh & Zuckerman (1982))*

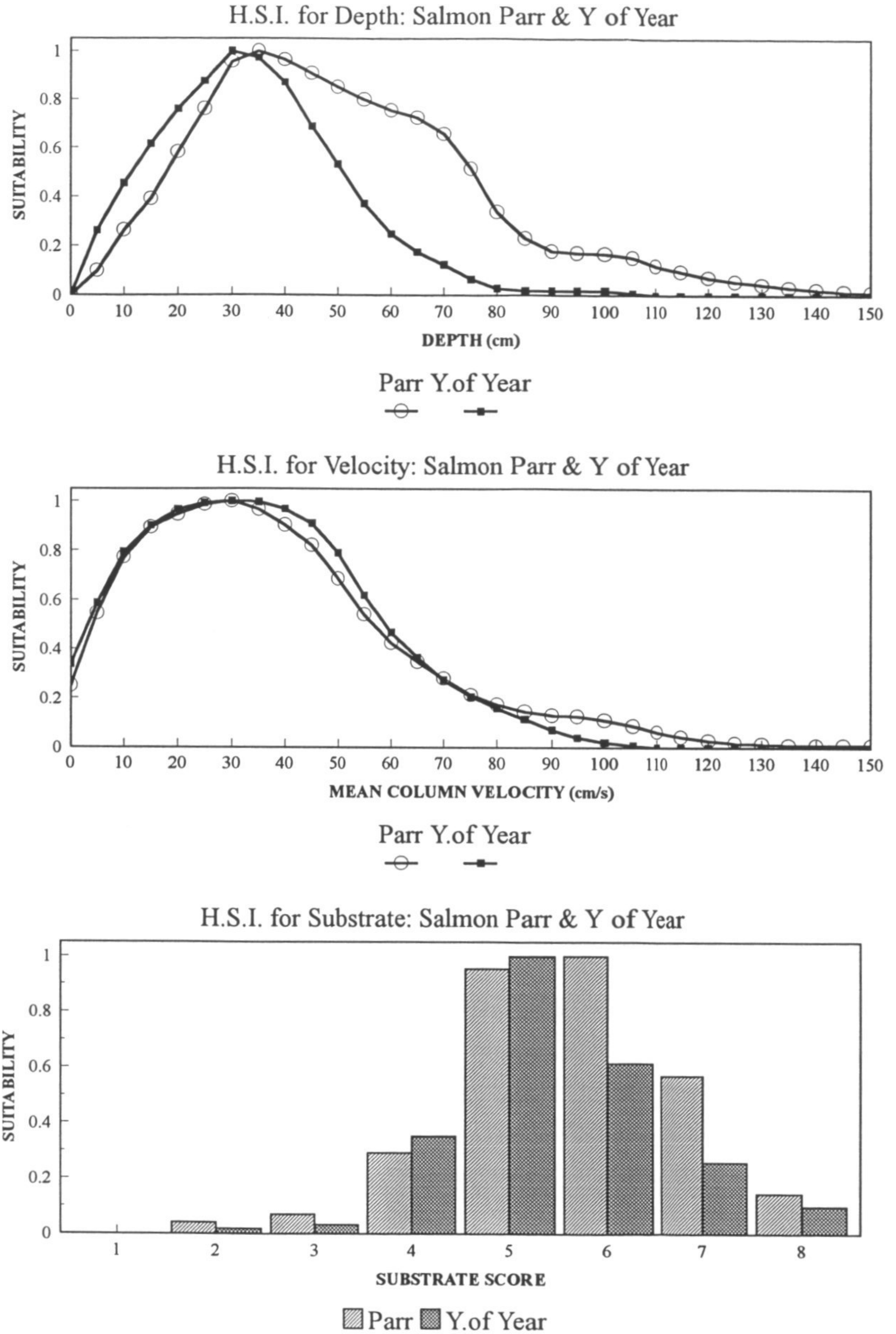
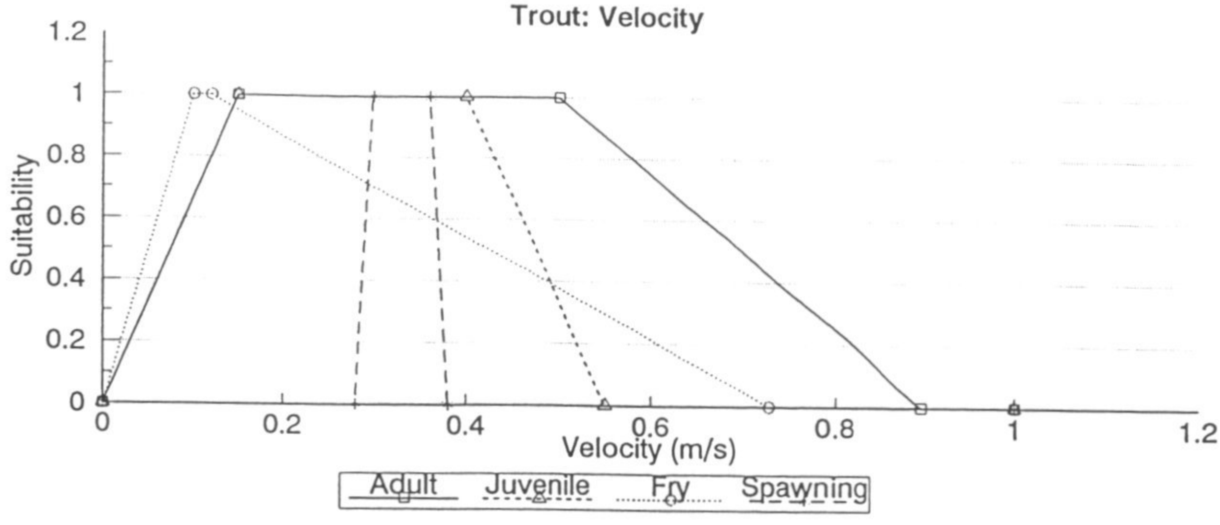
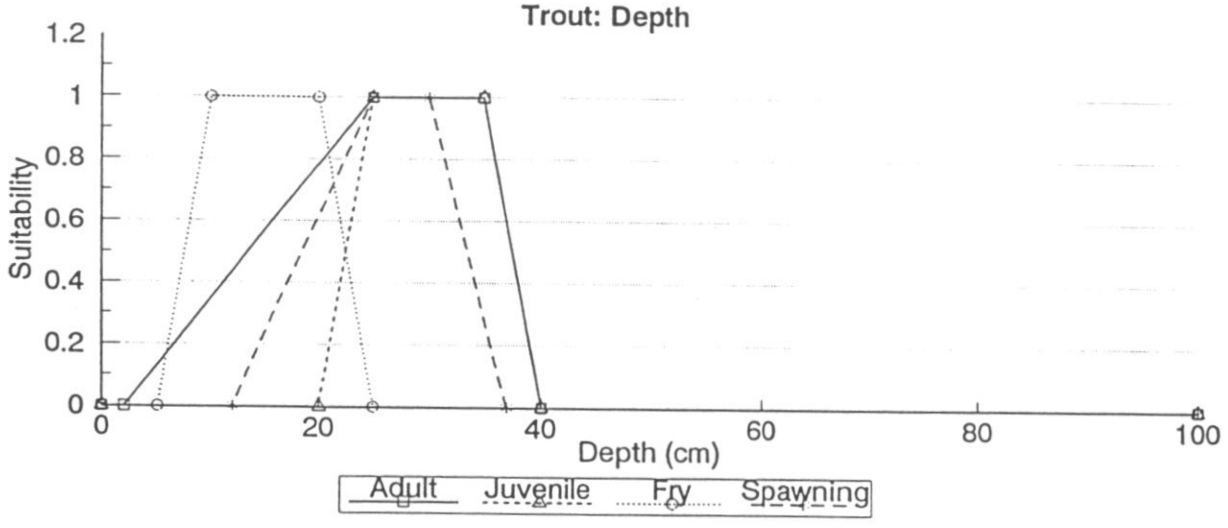


Figure A4 *Category I Habitat Suitability Indices: Salmon Parr and Young of year (Source: Heggenes (1990))*





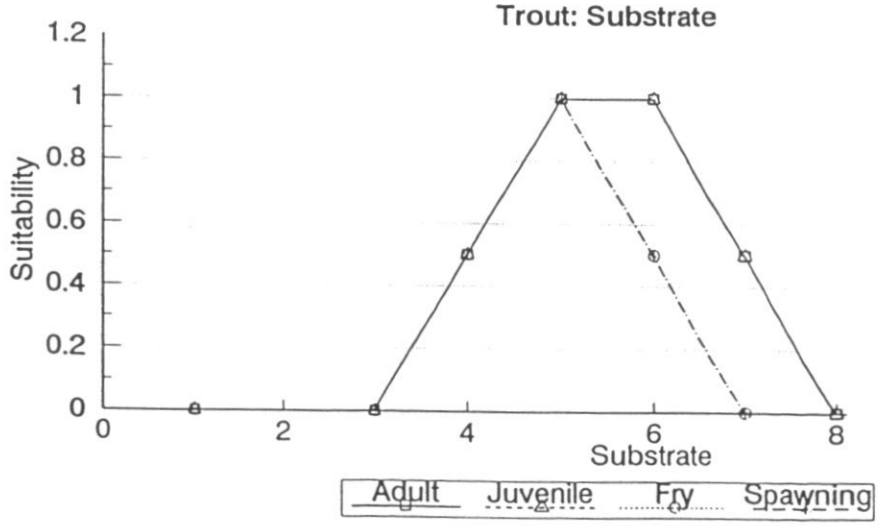


Figure A5 *Category I Habitat Suitability Indices: Brown Trout. (Source: Johnson et al, 1993(1))*

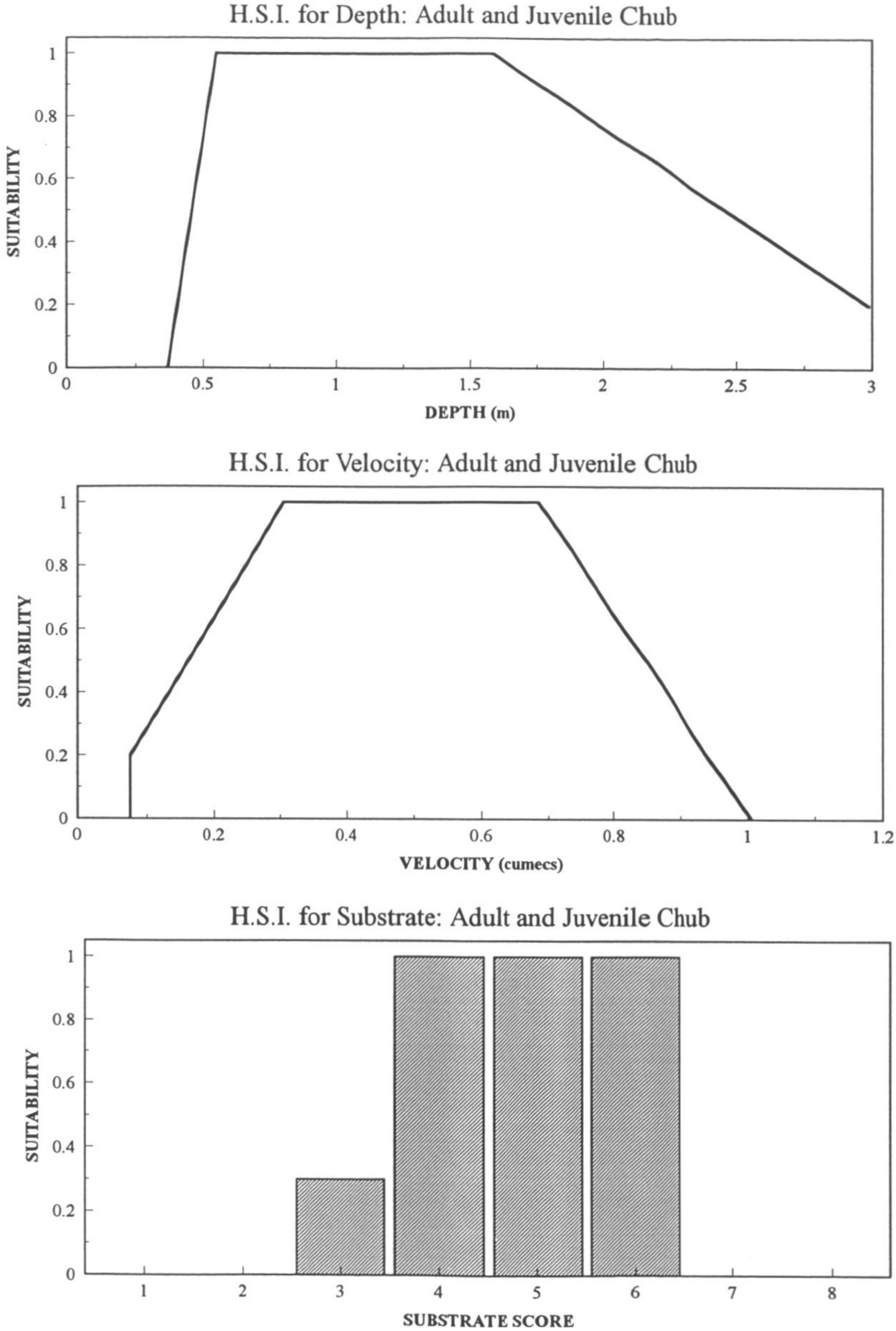


Figure A6 *Category I Habitat Suitability Indices: Adult & Juvenile Chub (Source: Bullock & Gustard (1991))*

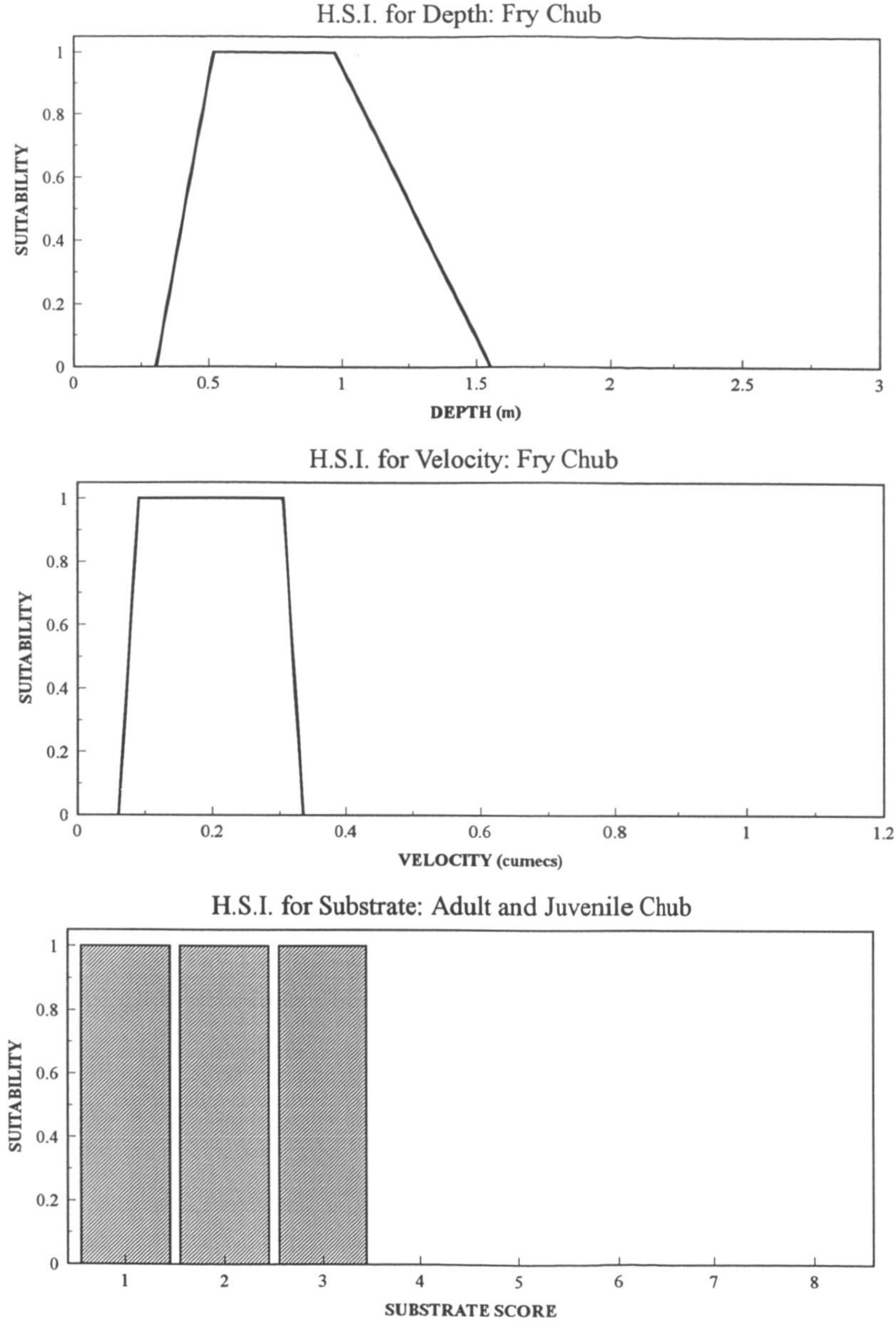
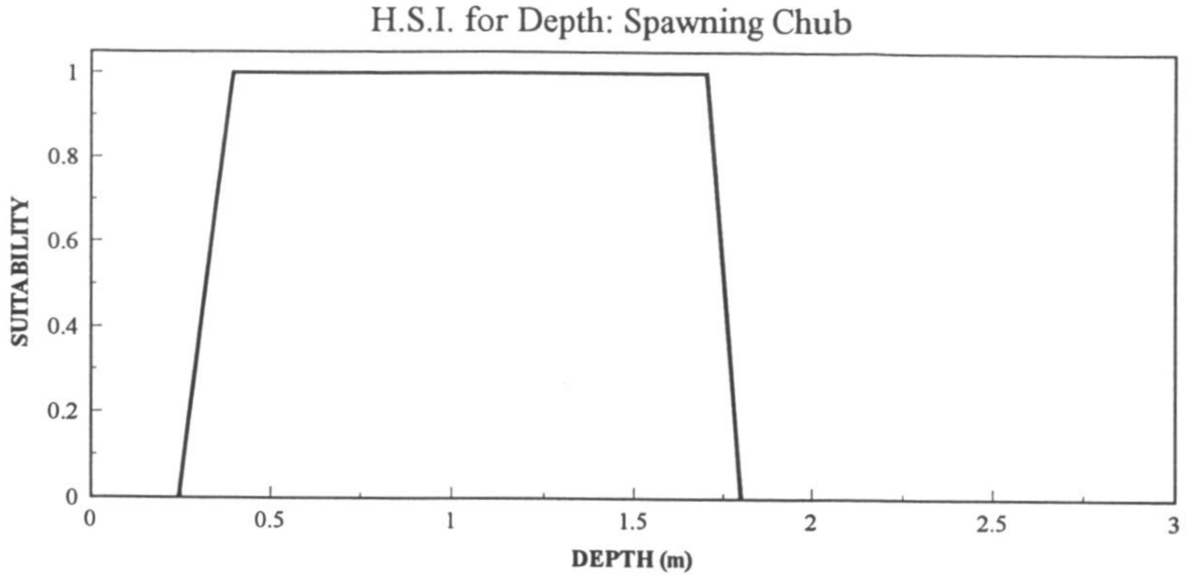
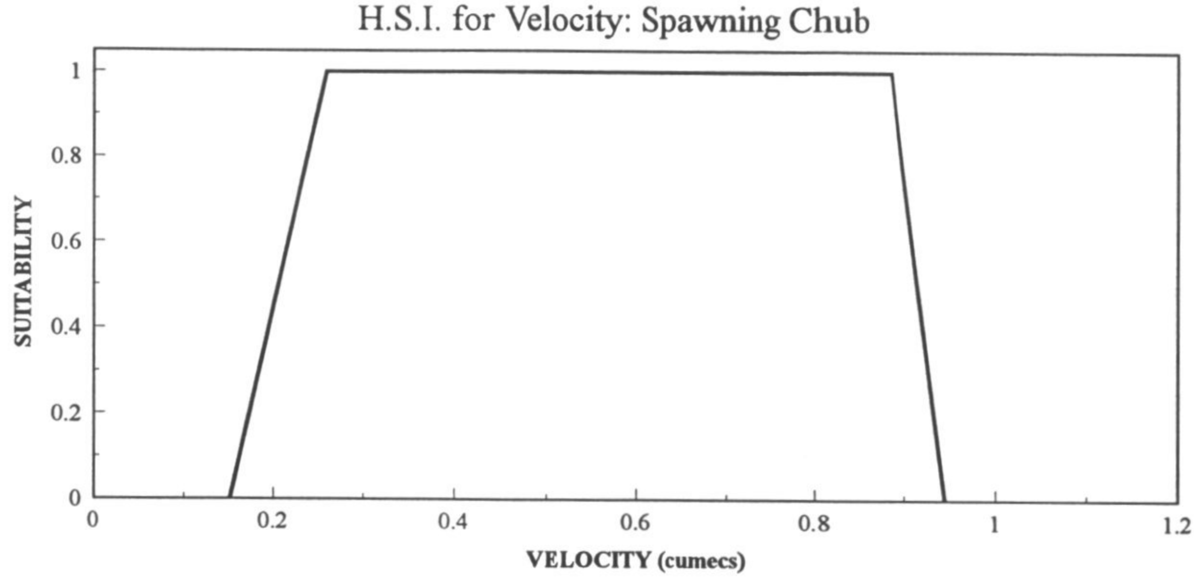


Figure A7 *Category I Habitat Suitability Indices: Fry Chub (Source: Bullock & Gustard (1991))*





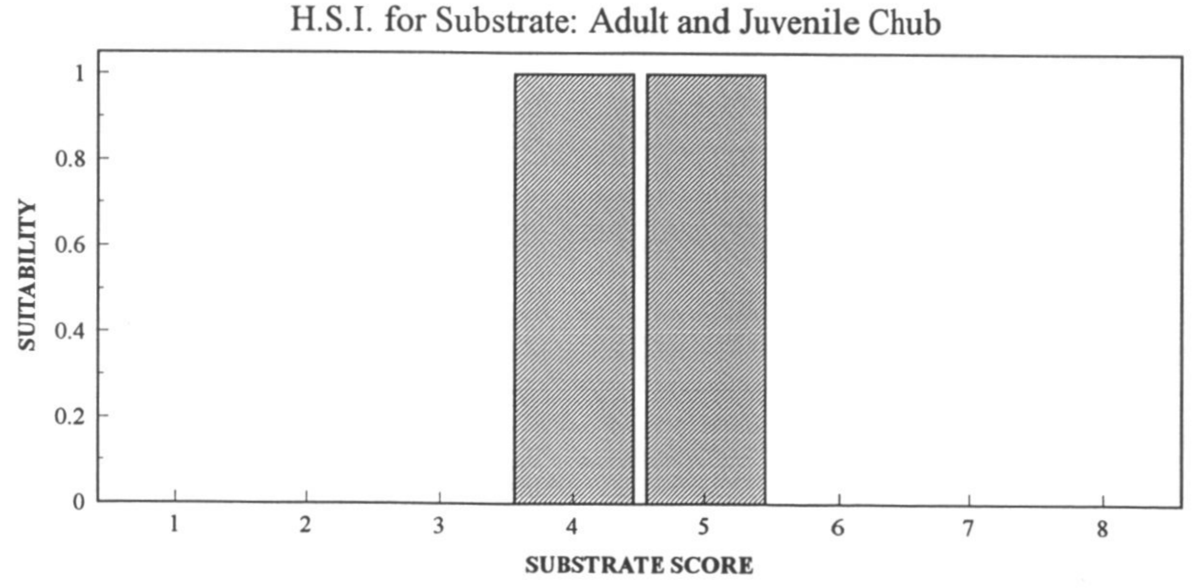


Figure A7 *Category I Habitat Suitability Indices: Spawning Chub (Source: Bullock & Gustard (1991))*